

Co-production of Silica From Geothermal Fluids

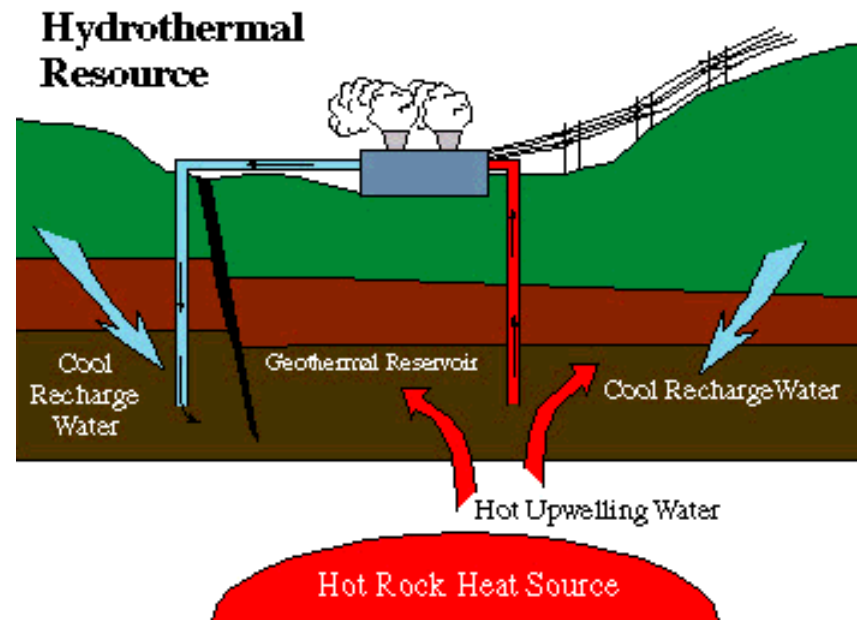
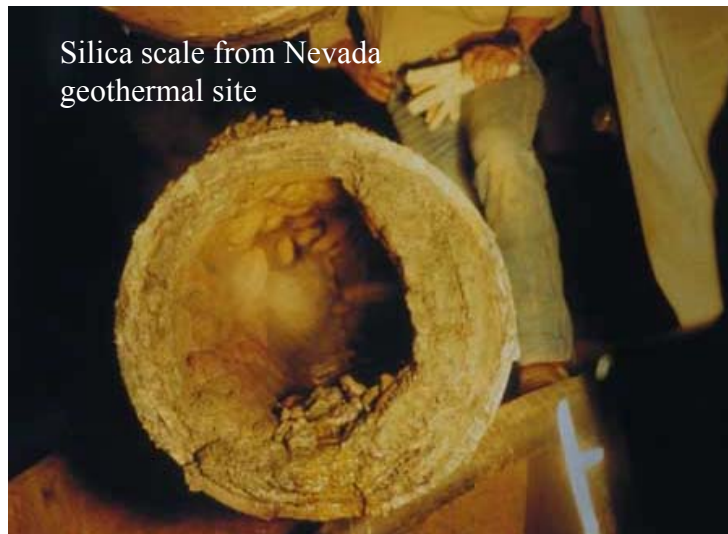


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Matching Funds
DOE Geothermal and Wind Technologies

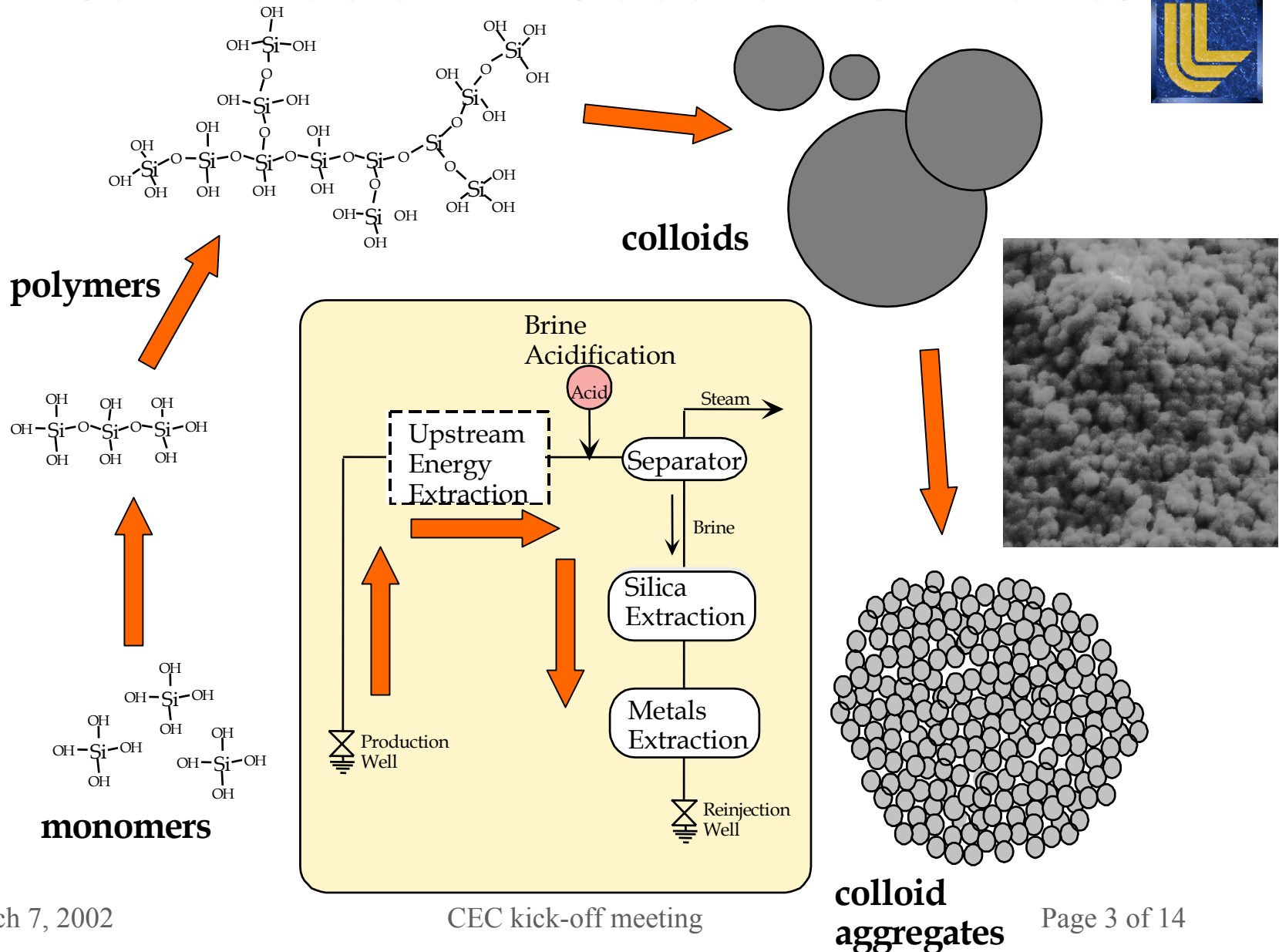
Overview



- Silica is always present in geothermal fluids and tends to precipitate with cooling
- Can we induce silica precipitation and produce a marketable by-product?



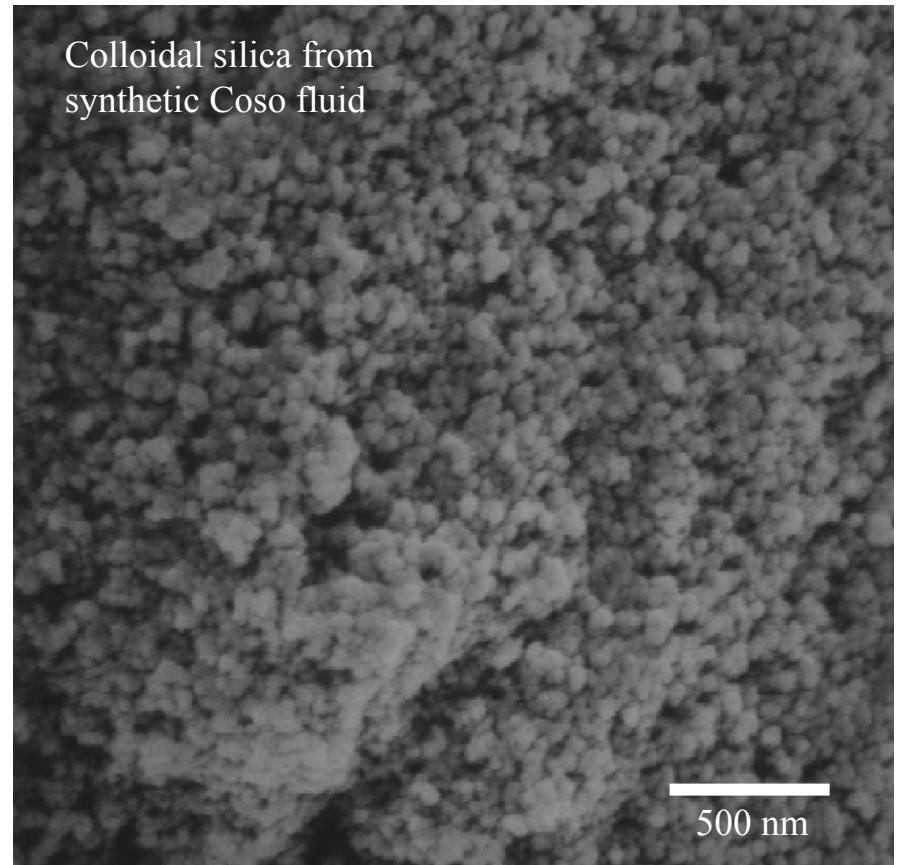
Silica Evolution in Geothermal Plants



Benefits



- Extract more energy from the resource
- Produce additional revenue from a marketable by-product
- Eliminate scaling and re-injection problems
- Allow additional downstream resource extraction



Project Plan



Goal: Develop a process that produces a marketable silica precipitate.

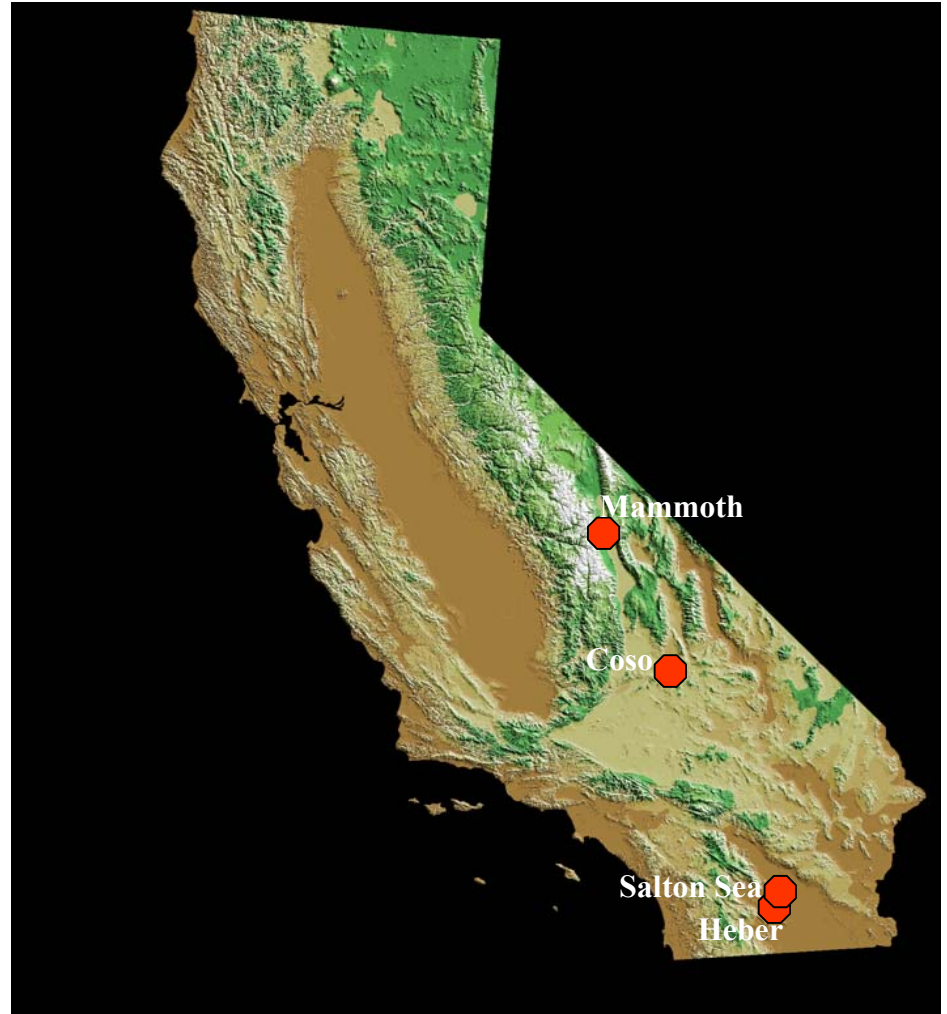
Work scope:

- Select field sites
- Carry out lab tests to identify promising silica extraction methods
- Extract silica at field sites
- Characterize precipitates
- Market testing
- Optimize process for markets

Potential Field Sites

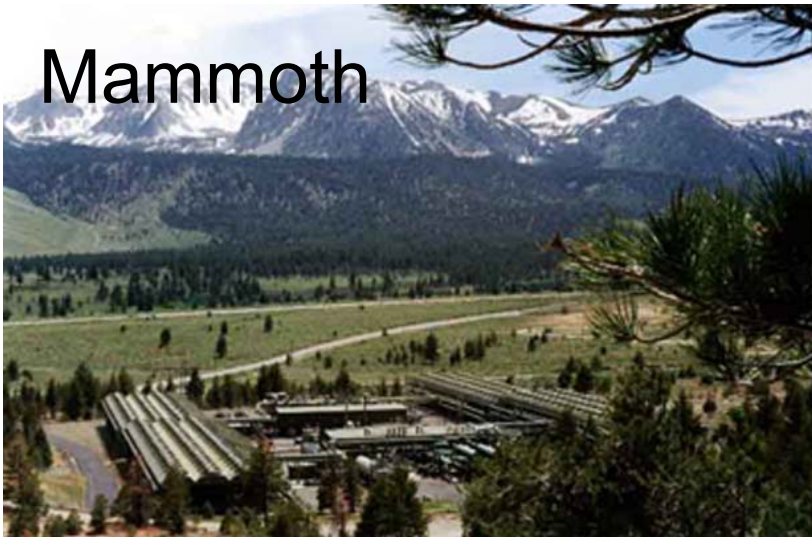


- ★ Mammoth (binary)
 - 1200 ppm TDS
 - 250 ppm SiO_2
- ★ Coso (flash)
 - 7000-10,000 ppm TDS
 - 600-800 ppm SiO_2
- ★ Salton Sea (flash)
 - 300,000 ppm TDS
 - 600-700 ppm SiO_2
- ★ Heber (both)
 - 14,000 ppm TDS



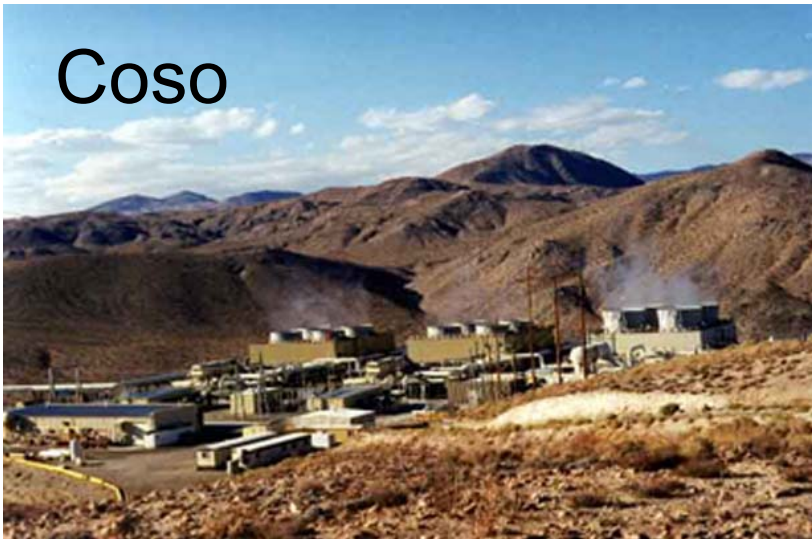


Mammoth



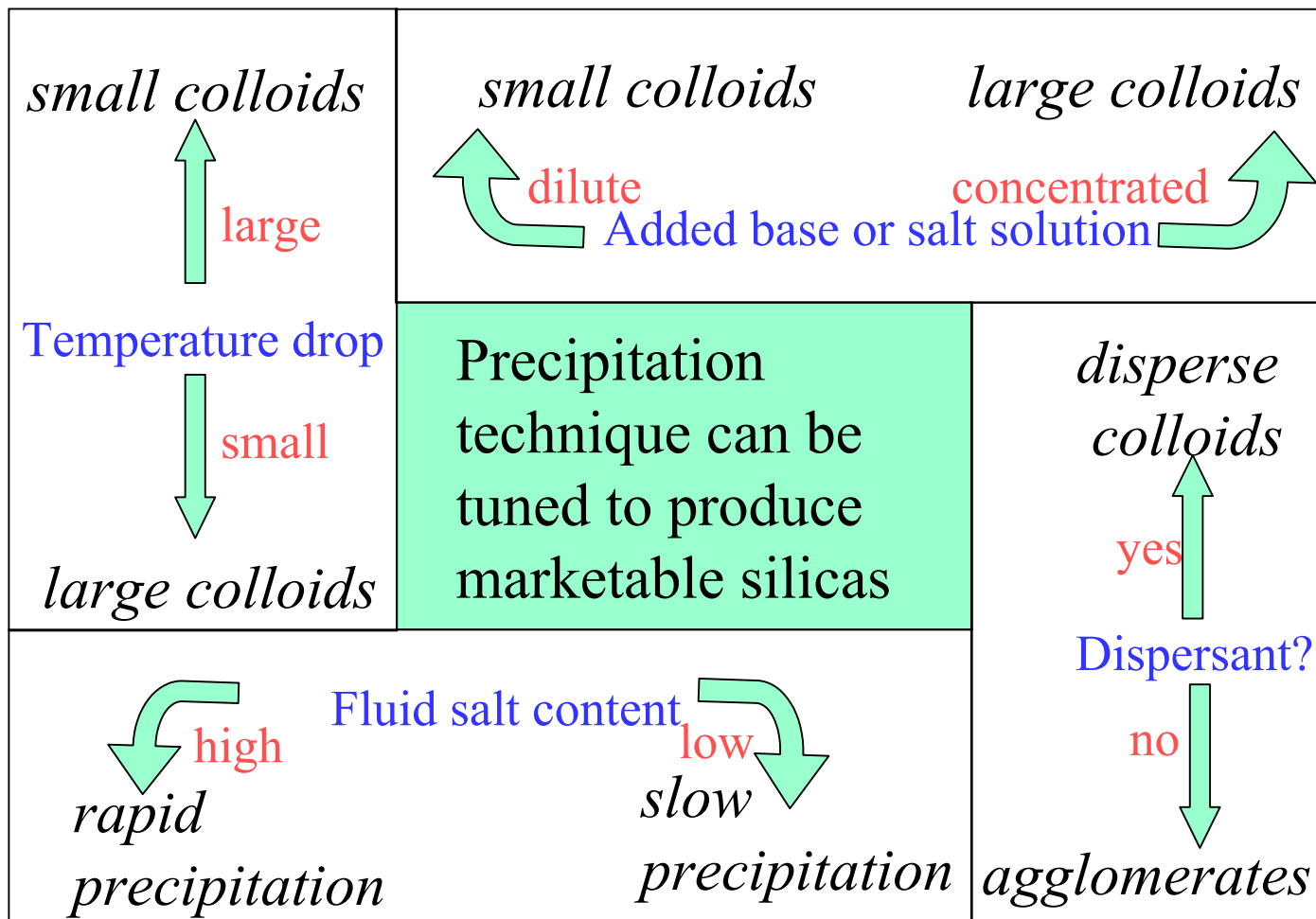
Need to lower silica concentration in spent geothermal fluid for use in water cooling facilities.

Coso



Co-produce silica for added revenue. Plant successfully uses brine acidification to control silica scale.

Chemical Controls on Silica Precipitation



Experimental Methods

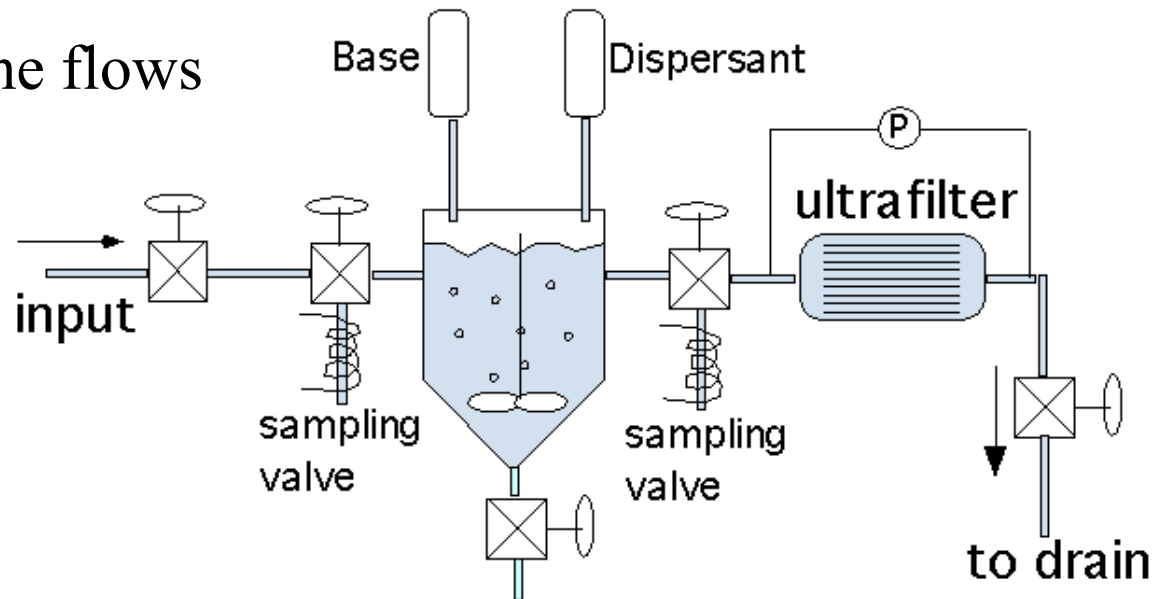


(1) Geothermal brine flows into stirred reactor

(2) Precipitation induced by

- pH increase
- cooling
- salt addition

(3) Silica precipitates captured for characterization and fluid analyzed to determine yield



Mobile On-Site Test Facility

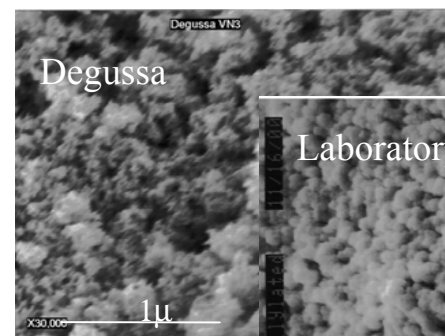
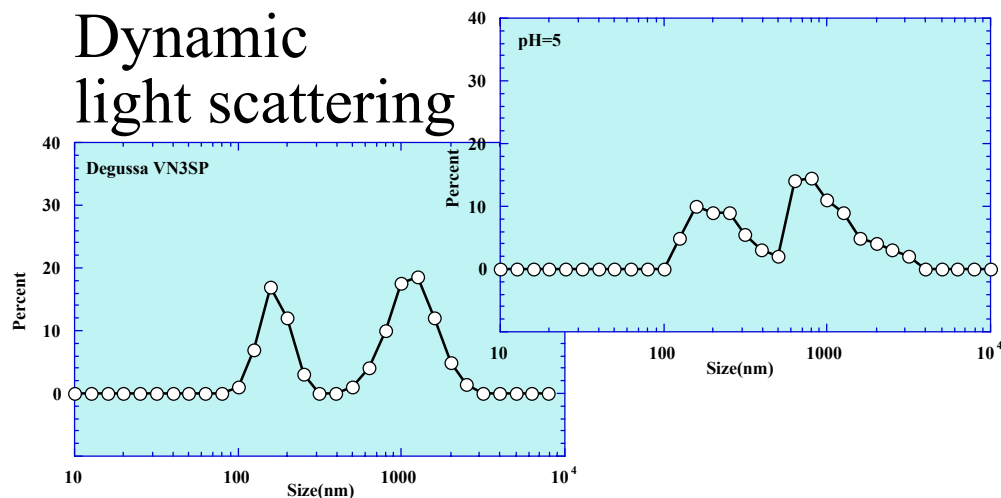


On-site analyses:

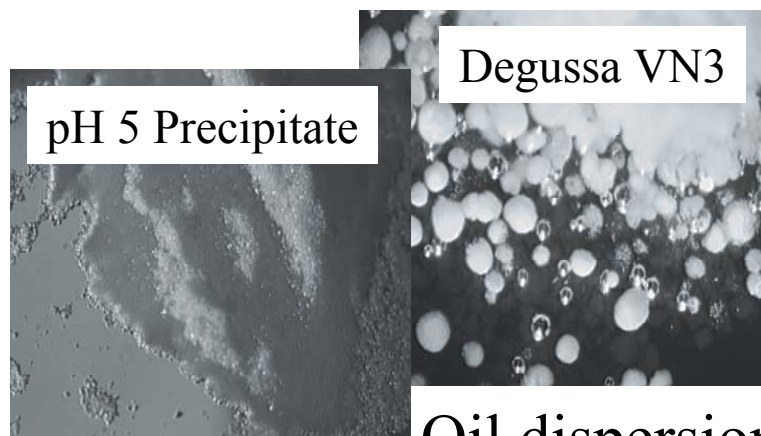
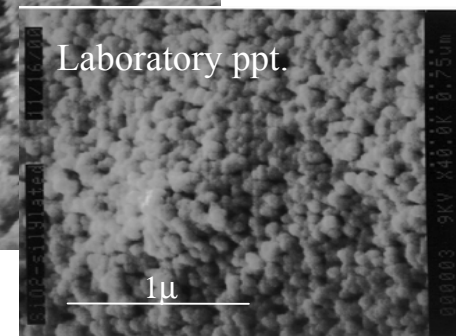
- particle size
- dissolved silica
- turbidity
- conductivity
- pH
- temperature-pressure



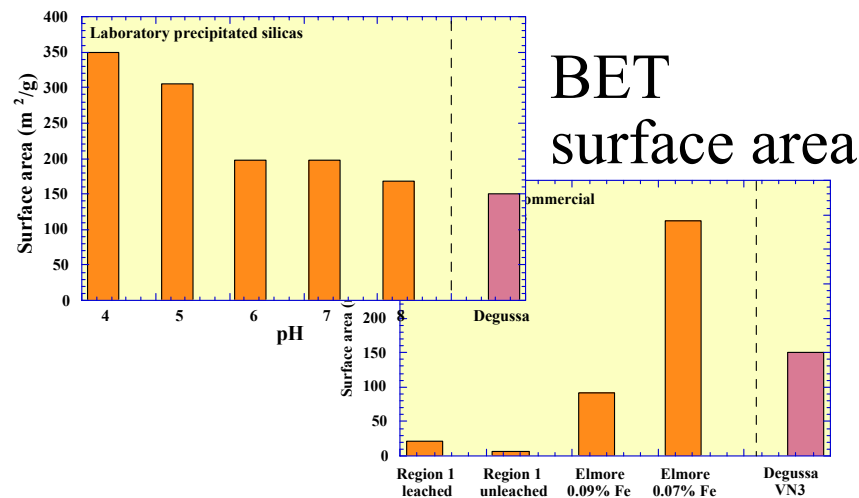
Characterization of Silica Precipitates



SEM



Oil dispersion



Commercial Silicas



Product	Cost/pound	Market Size
Cement additive	<10 ¢	large
Dessicant	2-10 ¢	large
Toxin removal	\$0.1-1	moderate
Waste&odor control	\$1-3 (retail)	moderate
Paper additive	\$1-5	moderate
Rubber additive	\$0.5-4	moderate
Polishing compound	\$5-10	small
Chromatography	high	tiny



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Salton Sea Geothermal Site



Today

What's Next?



- Additional sites
- Additional markets
- Lithium extraction
- Other metals

Personnel



LLNL

Bill Bourcier - Principle Investigator
Carol Bruton – Project Manager
Sue Martin – Lab principal
Bill Ralph – Field principal
Adam Wallace - Roustabout

Consultants

John Byers – Byers Rubber Consulting
Larry Lien – Osmonics Membranes
Don Askea – B. F. Goodrich
Don Eisenhower – American Colloid